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Annual Conference 2016

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Impact of combined wind and solar energy on the Swiss electricity system

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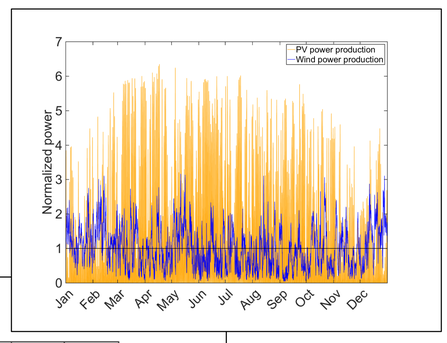
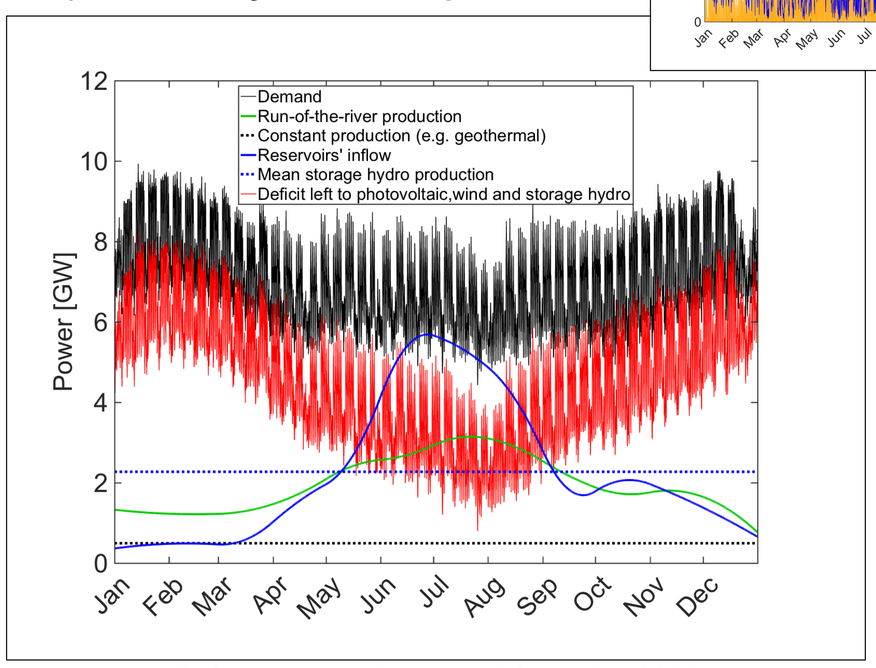
1. Introduction

- Electricity in Switzerland in 2014:
  - Demand: 61787 GWh
  - Storage hydropower: 19888 GWh
  - Run-of-the-river: 17243 GWh
  - Nuclear + Other: 30325 GWh

- Impact of a **fully renewable production**?





Swiss power production and demand in 2014

- Replace 24656 GWh with:
  - Geothermal: 4325 GWh
  - PV+Wind: **20331 GWh**

- Correlation Hydro / PV and anticorrelation with demand
  - **Seasonal storage?**
  - Role of **storage hydro?**

- High share of PV+Wind and high variability
  - **Short term storage?**
  - Role of **storage hydro?**

2. Methods

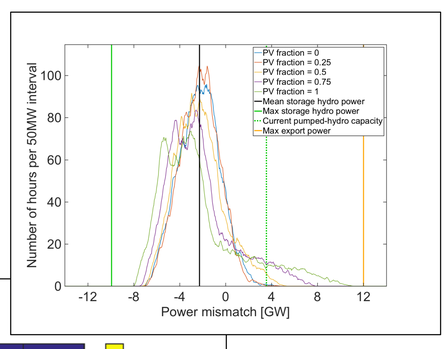
Non dispatchable generation
(PV, Wind, run-of-the-river, geothermal)

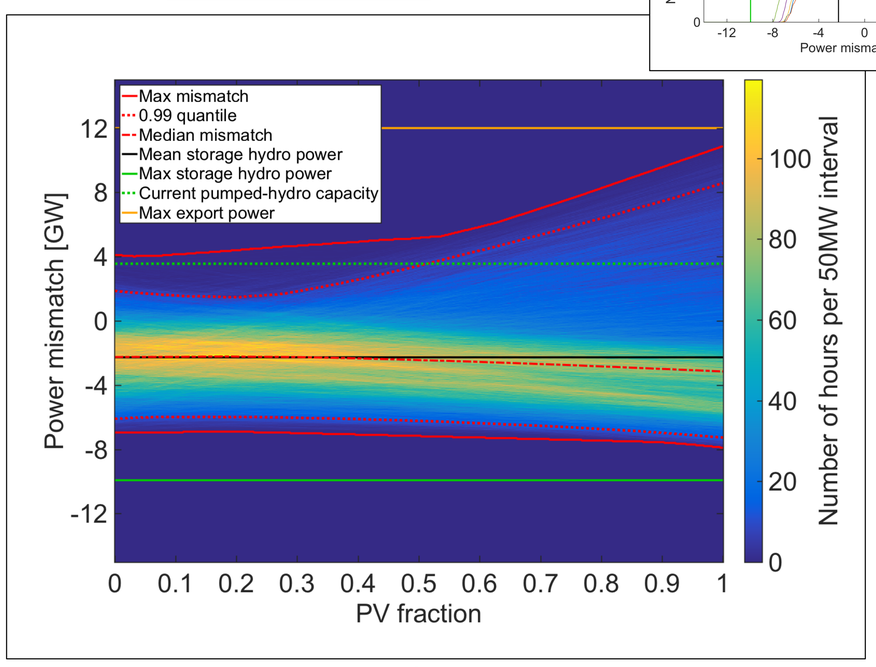
-

Demand

=

Power mismatch





Distribution of power mismatch
(non dispatchable generation – demand)

Balancing mismatches:

- Deficits:

Dispatchable generation
(storage hydropower)

- Overproduction:

Short term storage
+
Export

1. Balancing of instantaneous power mismatch through short term storage (within capacity limits)
2. Incorporating reservoir inflow and stored energy
3. Analyzing energy balance of the entire system

- Optimal use of storage hydropower
- Required import/export

4. Conclusion

With the current pumped hydro capacity (including Nant de Drance and Limmern) :
- **PV** should contribute **20 – 60 %** (4 – 12 TWh/year or 2.9 – 8.6 GW capacity)
- **Wind** should contribute **40 – 80%** (8 – 16 TWh/year or 4.4 – 10.2 GW capacity)

→ 3.9 – 5.2 TWh of **required import** if reservoir capacity is not increased

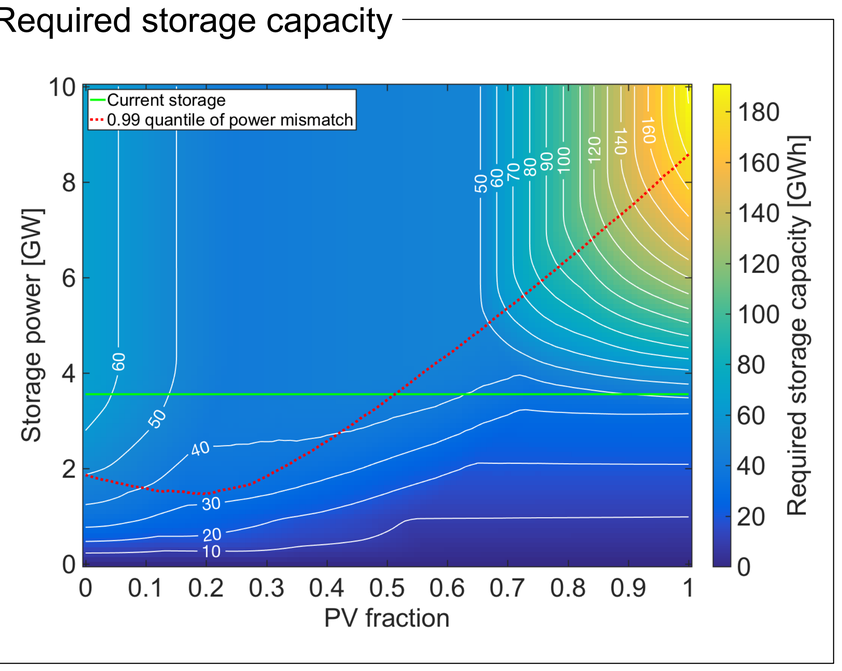
→ 10 – 30% of **increased reservoir capacity** to stay at current import

Data

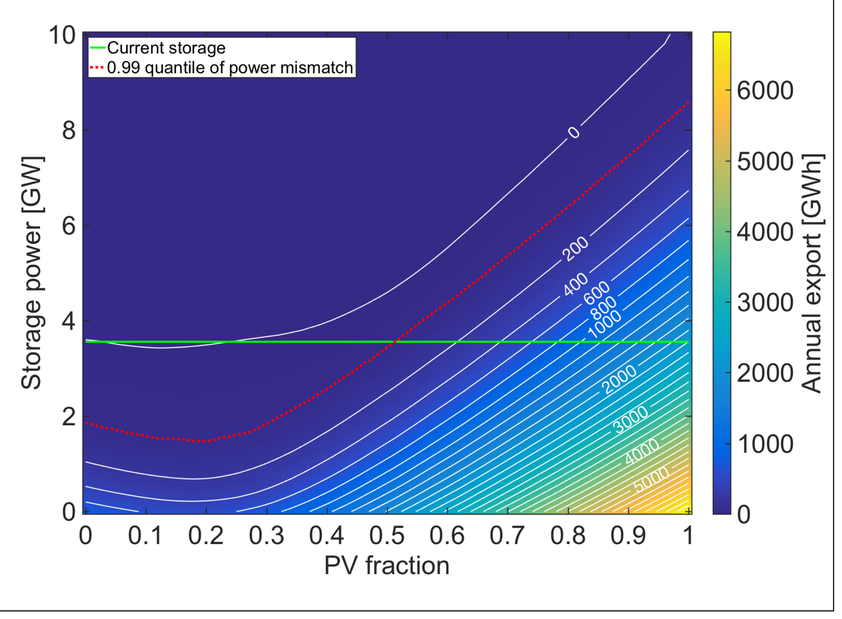
- PV production time series based on satellite-derived irradiance (MeteoSwiss)
- Wind production time series based on wind speed measurements (MeteoSwiss)
- Demand time series from Swissgrid (publicly available on their website)
- Run-of-the-river montlhy production and reservoirs' inflow from the Swiss Federal Office of Energy (SFOE)
- Storage hydropower and pumped hydro characterisitics from WASTA database (SFOE)

3. Results

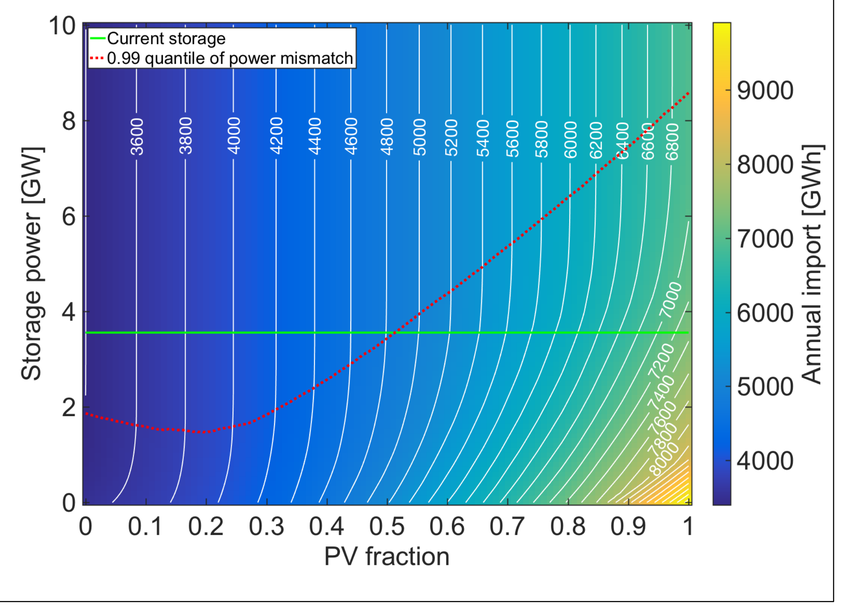
Required storage capacity



Annual forced export induced by overproduction



Annual required import



Effect of increased reservoir capacity on import